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Aeration of Grain in Storage

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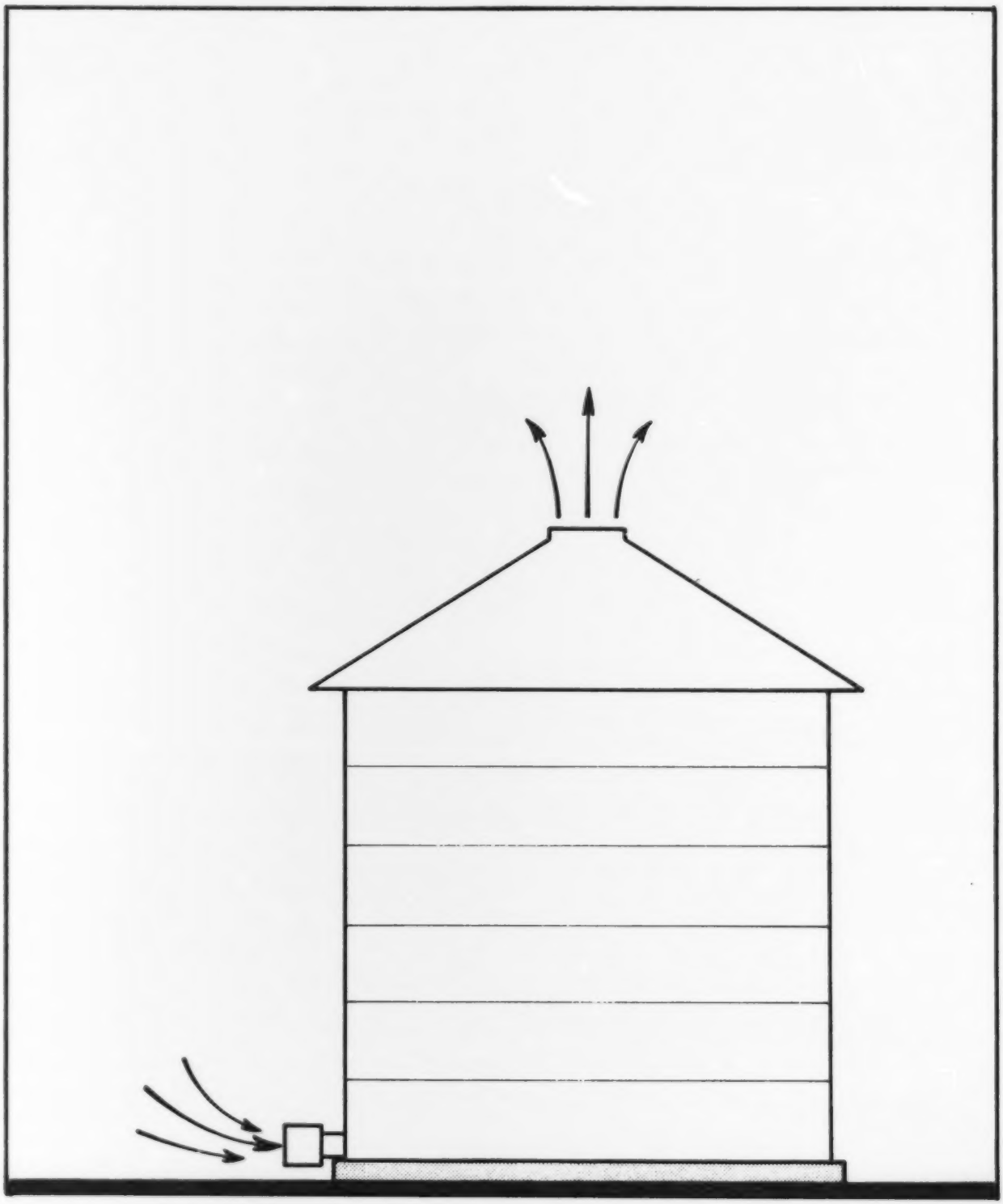

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Aeration of Grain in Storage

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In this publication, imperial units are used as the primary units of measurement. The SI (metric) units in brackets are not necessarily exact conversions, but are equivalent practical conversions and are values that would be used if the SI system was used alone.

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Introduction

Grain stored in large, well-sealed bins over 3,000 bu. (100 m³), and/or grain stored with large variations between grain temperature and ambient air temperature may be subject to significant moisture migration and possible grain spoilage. If this occurs, aeration may be used to accomplish several objectives: 1) equalize temperatures, 2) remove heat, 3) reduce mold and insect growth, 4) remove storage odor, and 5) equalize moisture.

Aeration is the movement of a small quantity of air, approximately 1/10 cfm/bu. (1.3 L/s • m³), through stored grain. The main purpose of aeration is to equalize the grain and ambient air temperatures. Aeration will, within limits, maintain grain condition. Aeration is not drying, although some drying may occur under certain conditions.

The need for aeration and the stages of grain conditions are explained in Figures 1 and 2.

Figure 1 indicates the temperature and moisture conditions that will enhance insect infestation, a drop in germination and fungal heating. Figure 2 indicates the length of safe storage for different temperature and moisture combinations without air movement.

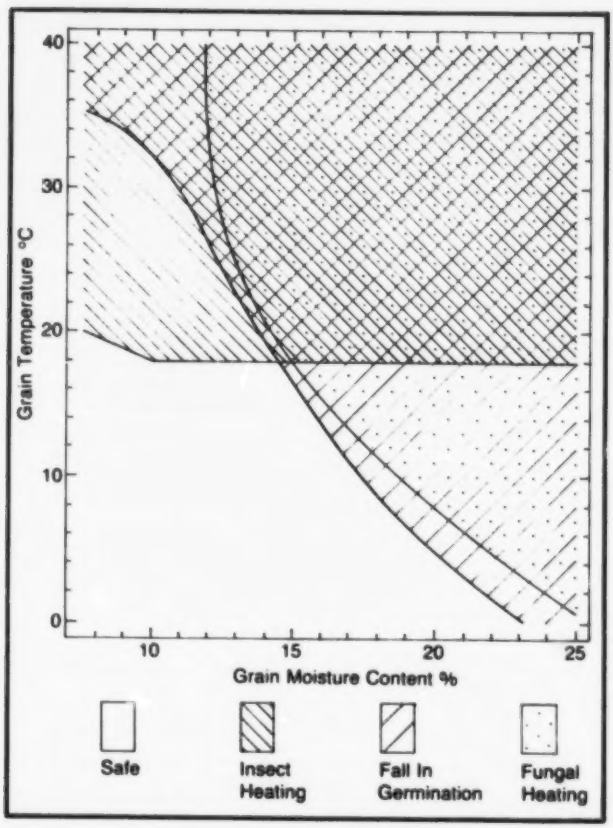

Figure 1. The effects of temperature and moisture on grain in storage

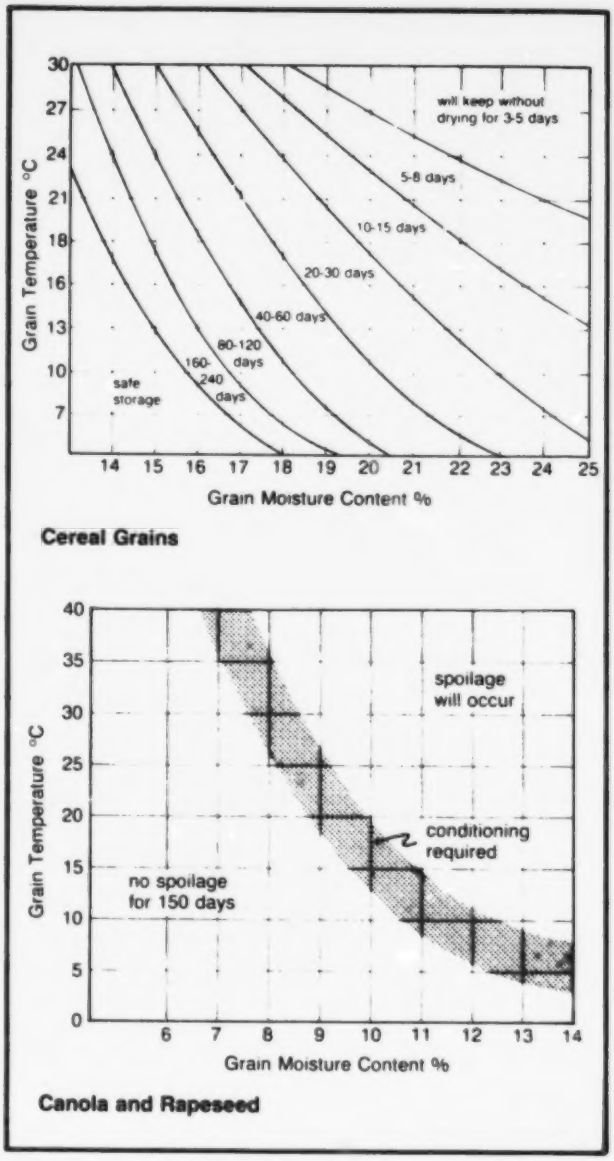

Figure 2. Storage time for grains at various temperatures and moisture contents

Principle of Operation

Figure 3 illustrates air and moisture movement during cold weather. This can, as indicated, result in spoilage at the top center of the bin. Figure 4 shows that when the outside air is warmer than the grain, there is a reverse flow of air and moisture, possibly resulting in wet and spoiled grain in the bottom center of the bin. Aeration disrupts this movement and evens out the temperature and moisture conditions throughout the bin, thus preventing this potential spoilage.

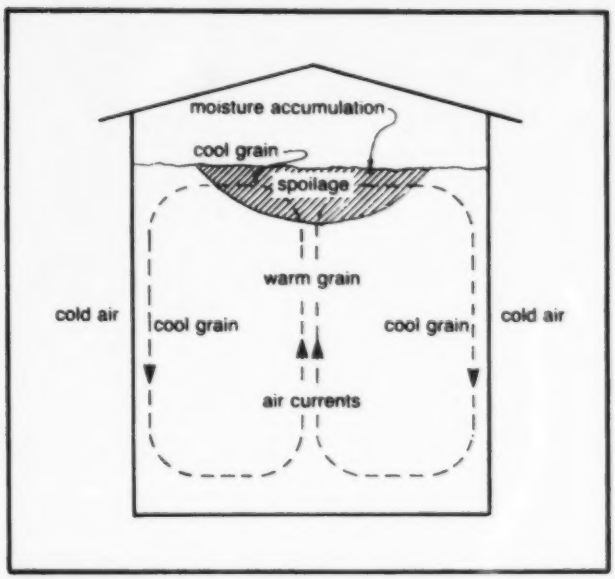

Figure 3. Fall air and moisture movement

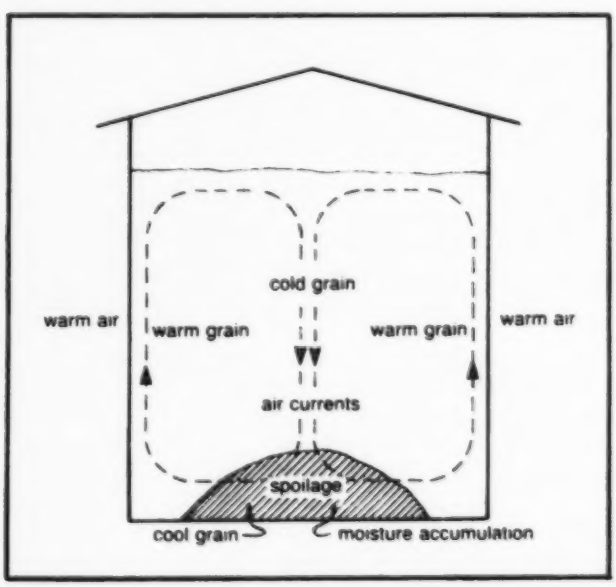

Figure 4. Spring air and moisture movement

Fall Operation

Dry Grain

- Probe stored grain to check for hot spots.

- If hot spots exist - **Aerate immediately.**

- If no hot spots exist, aerate only when the grain temperature is about 5°C higher than the daily average of air temperature. Aerate intermittently to maintain grain temperature within 5°C of the average air temperature.

- Discontinue aerating when the entire grain mass temperature has reached 0°C.

Tough and Damp Grain

- Begin to aerate as soon as the ducts are covered with grain.

- Depending on the grain moisture content, continuous aeration may be required.

- Probe stored grain. If hot spots cannot be eliminated by aeration, the grain will have to be moved, and possibly dried.

- Aerate until the entire grain mass temperature has reached -5°C or the grain is removed for drying.

- Continue to probe grain for hot spots.

Spring Operation

Dry Grain

- If the grain is to be moved by June, aeration should not be necessary; otherwise, warming the grain to 10°C is advised.

- Warm the grain in stages. Beginning in mid-spring, usually April, aerate when the average air temperature is about 5°C higher than the grain temperature. Be sure to warm the entire bin to the higher temperature level before stopping the fan.

Tough or Damp Grain

When the weather begins to warm up, probe the grain. If hot spots exist, **aerate immediately.** If the hot spots cannot be eliminated by aeration, the grain will have to be moved, and possibly dried.

Even if there are no hot spots, the following fan management guidelines should be used.

a) When Night Temperatures Drop Below 0°C

- Attempt to keep the grain mass as cold as possible. Do this by operating the fans only during cold periods, usually at night.

- Continue to probe the grain.

b) When Night Temperatures Remain Above 0°C

- Aerate when the average air temperature is about 5°C higher than the grain temperature. The fan should be operated long enough to change the entire bin temperature to the new level.

- Continue to probe the grain.

- Continuous aeration may be required depending on grain moisture content.

- Damp grain should be dried and tough grain may have to be dried.

Note - The fan should be operated long enough to change the entire bin temperature to the new level.

Selecting Components

Ducts

Ducts are commonly used as distribution systems for aeration. If the ducts are set below floor level; i.e., flush floor ducts (Fig. 5), a sweep auger may be used for complete bin unloading. If ducts are placed above the floor; i.e., on-floor ducts (Fig. 6), manual labor is required to completely empty the bin.

Aeration ducts may be placed in a variety of patterns to obtain a reasonably uniform air distribution. Common patterns are illustrated in Figure 7. The system illustrated in Figure 7-B provides the best distribution pattern and gives a higher concentration of airflow at the center, often a trouble spot. This pattern is desirable for bin diameters of 24 to 42 ft. (7 to 13 m).

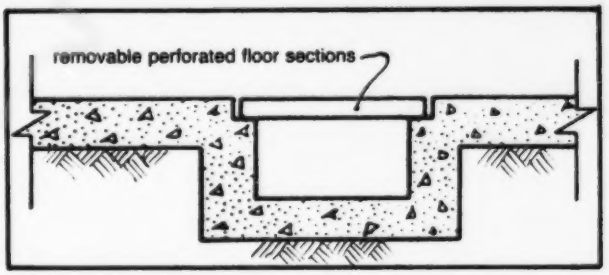

Figure 5. Flush floor duct

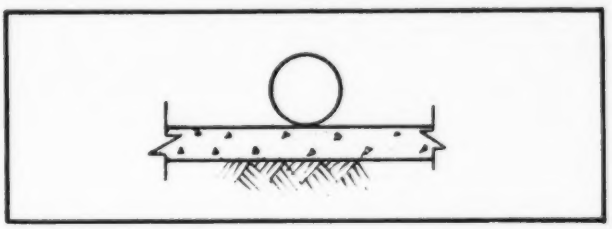

Figure 6. On-floor duct

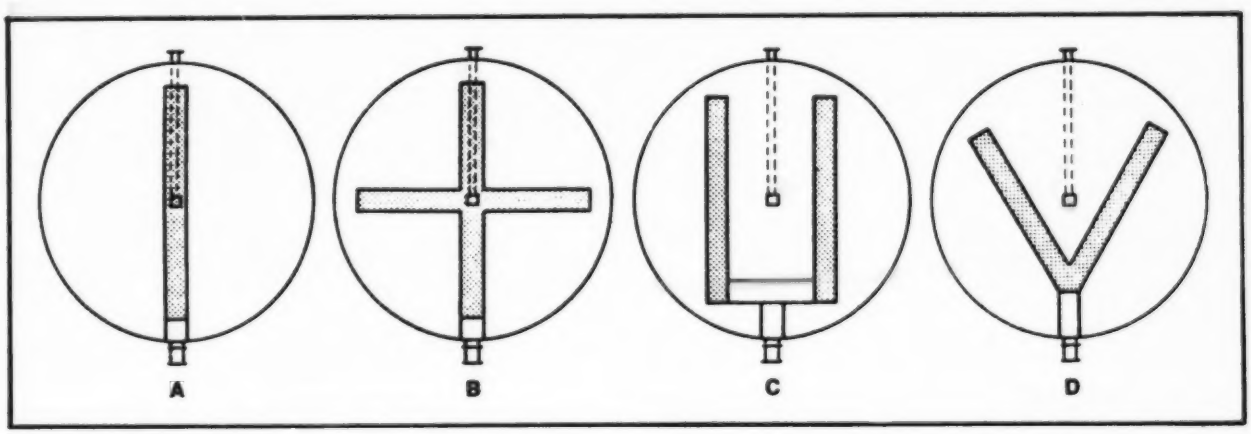

Figure 7. Aeration duct layouts

Fans

Fans are selected from the manufacturer's rating curves or tables to deliver the required air volume when operating against the expected static pressure. Axial fans (propeller-type) are commonly used for aeration because they produce high air volumes at low static pressures. However, air volumes delivered by axial fans fall off rapidly as static pressures increase above 4.0 in. (1000 Pa). Above this, centrifugal or in-line centrifugal fans must be used. The air may be either drawn down through the grain mass or be blown up through the grain mass. Figure 8 gives the expected static pressure for various grains and grain depths.

Design Procedure

The design procedure for an aeration system is:

1. determine bin capacity, select airflow rate and determine total air volume to be delivered

2. select ducts on the basis of cross-sectional area and surface area

3. determine operating static pressure

4. select fans to deliver the required air volume when operating against the static pressure

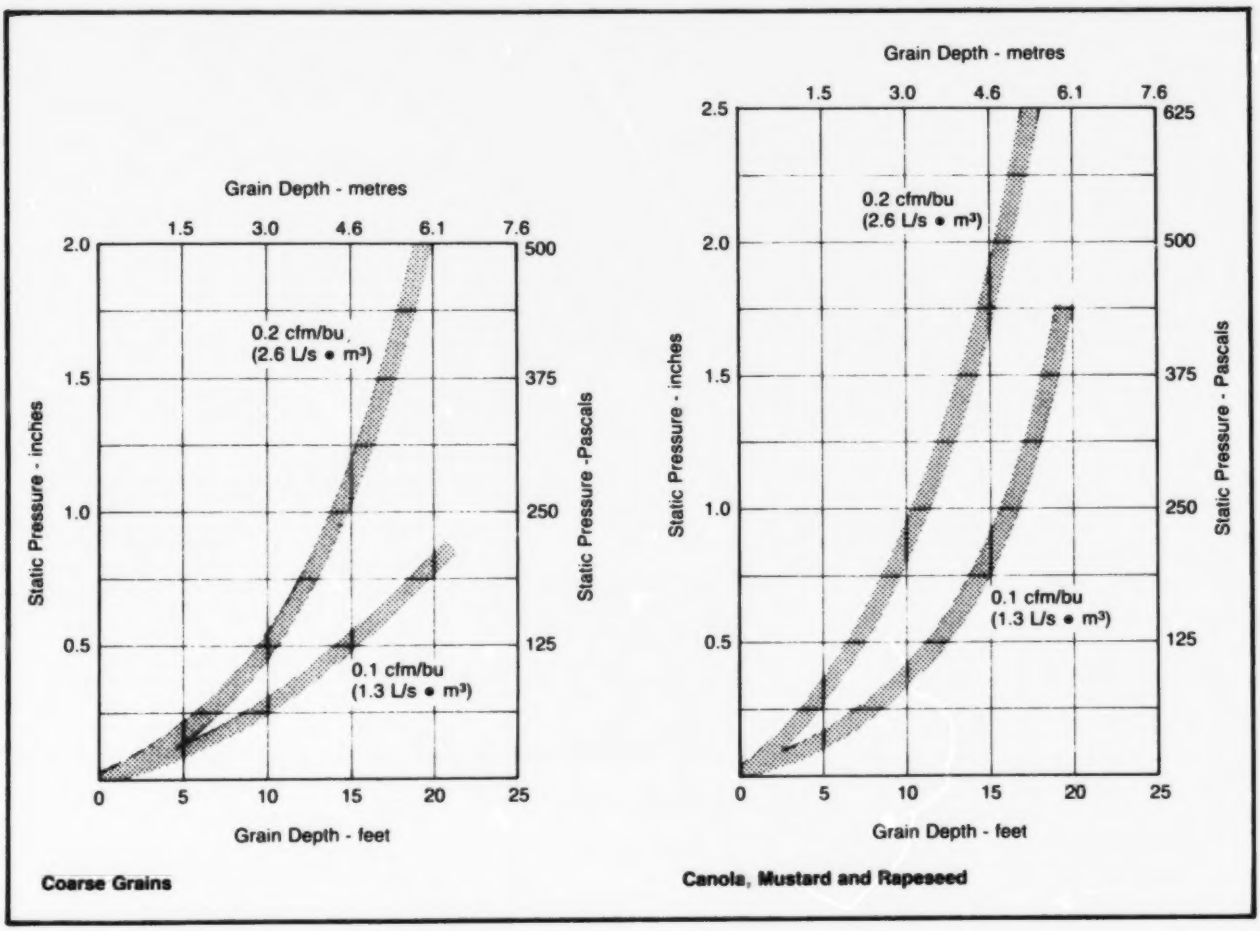

Figure 8. Static pressure developed for various grain depths and airflow rates

Determining Required Duct Size and Perforated Area

In a distribution system, two factors must be considered, duct cross-sectional area and perforated surface area. Recommended maximum air velocity in a duct is 1500 fpm (7.5 m/s). Minimum required duct cross-sectional area is total air volume divided by maximum air velocity.

$$\text{Minimum duct cross-sectional area (ft.}^2\text{)} = \frac{\text{Total air volume (ft.}^3\text{/min.)}}{1500}$$

$$\text{Minimum duct cross-sectional area (m}^2\text{)} = \frac{\text{Total air volume (L/s)}}{7500}$$

Recommended maximum velocity of air leaving the perforated area is 30 fpm (0.15 m/s). Minimum perforated surface area is total air volume divided by maximum air velocity leaving the duct.

$$\text{Minimum perforated surface area (ft.}^2\text{)} = \frac{\text{Total air volume (ft.}^3\text{/min.)}}{30}$$

$$\text{Minimum perforated surface area (m}^2\text{)} = \frac{\text{Total air volume (L/s)}}{150}$$

The perforated material should be at least 10 percent perforated.

For round on-floor ducts, the surface area is calculated at 80 percent effective, to account for the portion of the duct in contact with the floor.

Example

7000 bu. (247 m^3) bin; 19 ft. (5.8 m) high; canola at airflow rate of 1/10 cfm/bu. (1.3 L/s m^3).

1. Total air volume = 7000 x 1/10 = 700 cfm (247 x 1.3 = 325 L/s)
2. Duct cross-sectional area = 700/1500 = 0.5 $ft.^2$ (325/7500 = 0.04 m^2)

   Perforated area = 700/30 = 24 $ft.^2$ (325/250 = 2.2 m^2)
3. Expected static pressure (Figure 8) = approx. 1.6 in. (400 Pa)
4. Fan required to deliver 700 cfm (325 L/s) @1.6 in. (400 Pa) static pressure.